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November 20, 2000

Nolte Associates
1750 Creekside Oaks Drive
Suite 200
Sacramento, CA 95833

Attention: Mr. Steve Hiatt

Re: The Reno Rail Corridor, Reno, Nevada
MRCE File No. 9432

Gentlemen:

In accordance with our agreement of August 24, 2000 MRCE has completed its review of the proposed Reno Rail Corridor project which proposes the below grade depression of the Union Pacific railroad tracks which pass through the center of the City of Reno.

MRCE SCOPE OF SERVICES

MRCE's scope of services is limited to the review of the diaphragm wall alternative for the construction of the below grade structure, including a review of the project documents and details, the provision of slurry walls specifications and recommendations on construction and an estimate of wall seepage at a typical cross section of the structure.

AVAILABLE DOCUMENTS

Nolte Associates has provided the following documents for MRCE's review:

1. Plan and profile drawing of alternative 3a which is the City's preferred alternative.

2. Geotechnical engineering report prepared by Kleinfelder dated May 2000.

3. Draft Analysis of Wall Systems report dated July 10, 2000.

4. Kleinfelder's draft of Post Construction Seepage Analysis report dated 7/7/00.

PROJECT DESCRIPTION

The project is approximately 2.5 miles in length and is located within the existing 54 feet wide Union Pacific Railroad right-of-way. The depressed rail is to be located in a structure of approximately 29 ft. depth, which would require excavations in the order of 35 feet, depending on the type of invert structure selected. Portions of the trench structure will be located below the existing ground water levels as measured at the site. Extreme groundwater levels are projected to be higher than those measured levels. The proposed structure that is the subject of this review consists of the two parallel diaphragm walls, approximately three feet thick, carried to approximate depths of 42 feet below grade. During excavation the diaphragm walls are to be supported by struts spanning between the diaphragm walls or by tieback anchors. Where present, the permanent invert slab will provide support of the walls once the structure is completed. (Drawing D-1). Struts and/or tieback anchors will also provide permanent wall support.

SUBSURFACE CONDITIONS

Soil conditions along the alignment are separated into two basic groups, the upper soil profile consists of fine grain soil deposits and man made fills while the deeper soil profile consist of very coarse grain glacial outwash materials consisting of heterogeneous mixtures of sands, gravels, cobbles and boulders. Previous reports indicated that boulders up to 8 feet in diameter were encountered in the outwash formation during construction at other projects within the City. The lower soil strata described has a moderate to very high permeability. Contaminants have been identified at various locations throughout the project and are anticipated to have an adverse affect on potential dewatering operations.

GROUNDWATER

We understand that, in general, the groundwater quality is considered to be good. However, construction generated water must meet stringent discharge standards prior to being discharged into the Truckee River. Contaminants identified by Kleinfelder during the site investigation would need to be removed from the water prior to such discharge. Groundwater elevation map provided by Kleinfelder [Plate G3] indicates an approximate 30 foot change in the elevation of groundwater from Ralston Street in the west to Morrill Street in the east. This is an approximate gradient of 0.7 feet per 100 feet.

LEAKAGE IN DIAPHRAGM WALL SYSTEMS

Leakage can occur within a diaphragm wall panel itself, at the vertical panel joints, at the bottom invert slab/ wall joint, or through the invert slab itself. Leakage within a panel can be caused by soil or slurry contaminated concrete trapped in the reinforcing, at blockouts or at the joint during panel concreting operations. Occasional problems within the body of a cast diaphragm wall panel occur as a result of cold joints which result from interruptions in the placement of concrete or the loss of the tremie seal during concrete placement. Contaminated concrete can result from 1) overly dense reinforcement, 2) long wall lengths in plan, 3) box outs or tieback anchor sleeves, 4) narrowness of the wall, 5) the spacing of the tremie pipes, 6) concrete fluidity and shrinkage, 7) poor end stop details or 8) end stop extraction problems. Highly reinforced walls with inserts or boxouts are prone to have greater problems then thicker less reinforced walls that are not penetrated by boxouts or inserts. Tieback anchor sleeves prove to be most troublesome of all penetrations through the wall. Cleaning of the slurry is essential prior to placing concrete.

Joint problems also occur if adjacent panels are out of verticality in opposite directions. Slurry wall specifications usually permit the wall to be out of verticality by 0.5% to 1.0% of the depth of the wall, that means that one wall panel could be out of position as much as 0.3 feet outward while the adjacent panel could be out of position by as much as 0.3 feet inward at the joint. As a result, for a 3 foot thick wall, the effective wall thickness at the joint can be reduced to 2.4 feet.

The majority of leakage in the slurry walls occurs at the vertical joint between adjacent panels or at the panel connection to the base slab, the latter being more difficult to correct. Vertical joints are slip formed by tubes, or other devices that are placed at the end of the panel prior to concreting and then extracted as the concrete is placed in the panel and then hardens. These joints do not normally incorporate any water stop details. Soil and groundwater conditions play a role in leakage through wall imperfections, obviously high water levels and walls cast against highly pervious soils will exhibit more severe leakage. Large losses of bentonite slurry may occur during excavation in pervious ground, minimizing the beneficial plugging of the ground and the development of filter cake on the trench walls. High quality thoroughly inspected construction is essential, thicker walls, cast in short panel lengths provide superior vertical joints and less risk of contaminated concrete collecting at the joint between panels. The use of permanent steel beam stop ends provides a superior joint between panels and a prolonged path for any flow of water through the joint. Patented methods are available for inserting water stops at the vertical joint, however, these water stops are often damaged and ineffective, and in some cases actually provide a path for the flow of water through the joint. Poorly formed vertical panel joints can yield as much as one gallon per minute per joint during construction. For the purposes of this study, we can assume that 10% of the vertical joints will require repair during construction and that these joints, spaced at 20 feet on center will produce an average leakage of a half gallon per minute per 100 feet of exposed wall until exposed during excavation and then repaired. Leaks near the bottom of the excavation will produce water longer since they will be exposed last.
Corrective work at the joint can reduce these leaks to patches of moisture on the face of the wall. Some resealing of leaks may be required during the life of the structure if wall movements occur as a result of temperature change or frost action at the joints.

Leaks at vertical joints are sealed during general excavation by cement or chemical grouting through the joint or outside the wall behind the joint. Major leaks are rendered watertight by these methods. Occasionally it is necessary to remove and replace defective concrete after the leak is sealed. These leaks may reopen during subsequent stages of excavation or during severe seismic events and may need resealing. Support systems also influence the behavior of vertical joints between panels, for example improper sequencing of the installation or removal of struts or anchors could cause displacements across the joint and produce leaks.

The connection of the invert slab to the diaphragm wall will most probably provide the greatest source of water infiltration into the finished structure. This joint is extremely difficult to form since water stops attached to the reinforcing steel cage are placed in the lower key blockout and are only effective for the length of the reinforcing steel cage. The space of about 18 inches that remains between the cages of adjacent panels is therefore unprotected by a horizontal waterstop. The vertical joint between any water stop used in a vertical panel joint and the horizontal water stop would also be a source of leakage (Drawing D-2). For the purposes of this study, we assume an average leakage of 10 gallons per day per 100 feet of finished structure, for the horizontal joint leakage.

PROCEDURES FOR WATER TIGHT DIAPHRAGM WALL CONSTRUCTION

Specifications normally place the responsibility for the water tightness of the diaphragm wall on the contractor, recognizing that construction quality control will have the major effect on the water tightness of the system. However water tightness can also be affected by design details. A suitably water tight diaphragm wall system requires the collaboration of an experienced designer and an experienced contractor who jointly select details and procedures which will provide optimum water tightness.

The designer should select suitable reinforcing, insert, and blockout details, panel joint details, horizontal invert slab/diaphragm wall joint details and waterproofing system for the invert slab. The contractor, should select tools and personnel capable of executing the design as indicated and should provide proper desanding and concreting procedures to assure that optimum concrete placement is achieved. The concrete mix design is critical to proper placement, the mix should be wellgraded, have ¾" rounded stone, be rich in cement and sand and maintain an eight inch slump. The constructor of the invert slab should take all measures necessary to properly clean the floor key, waterstops and any other connection devices between the diaphragm wall and the invert slab.

The diaphragm wall contractor should be required to seal all panel and vertical joint leaks as they become evident during excavation and should maintain on site forces at the ready to seal any leaks that appear. Poorly concreted sections should be removed and replaced as the excavation proceeds downward. Chemical or cement grouting should be used as needed. Temporary tieback anchors should be properly detensioned and sealed by steel plate covers welded to the tieback sleeve insert. On occasion it is necessary to grout leaks that develop at the sleeve.

STANDARDS FOR WATERTIGHT DIAPHRAGM WALLS

MRCE requires that the diaphragm wall Contractor on MRCE projects be responsible for providing and maintaining a watertight wall system. The term "watertight" as used here, requires that "there shall be no running water nor formation of water droplets on wall or panel joint surfaces. The formation of moist patches on the wall or panel joint surface is acceptable."

MRCE has reviewed current British and German Standards, and finds no specific criteria for allowed water infiltration. On recent MRCE projects in Germany, local officials have imposed construction seepage limits of one liter per second per 1000 square meters of structure exposed to water, regardless of construction method used. This limit would permit 280 gallons per day per 100 linear foot of structure at this site.

ESTIMATE OF LEAKAGE

We have prepared Drawing No. D-1, attached, showing a diaphragm wall construction with struts and a jet grout plug. We used this drawing as our base line for estimating leakage into the site during construction and into the finished structure upon completion of construction. We have performed preliminary checks of the buoyancy of the structure during construction and as a completed structure. We believe that a 14 foot thick jet grouted soil plug (from the base of the invert slab downward) would provide a suitable plug for sealing the excavation during construction at the deepest section of the structure. We are showing a partial embedment of the diaphragm wall below the finished invert slab. The depth of embedment is to be determined through structural design and considerations of leakage between the jet grout plug and the diaphragm wall. We have also determined that an approximate 6 foot thick reinforced concrete invert slab would be sufficient to resist buoyancy after completion of the construction. The impermeability of the invert slab could be significantly improved with a waterproofing membrane. The 6 foot invert slab dimension should be verified during structural design. We have also assumed a 3 foot thick reinforced concrete diaphragm wall is adequate for structural purposes. For our seepage analysis, we have assumed ground water is 22 foot below existing grade indicated on your documents.

For the temporary condition during construction, we have estimated seepage through the diaphragm wall panel, through the jet grout plug, through the joint between the jet grout plug and through the diaphragm wall. For this temporary condition, at the deepest section of the project, we estimate a maximum seepage of 4,000 gallons per day per 100 foot of structure, and a minimum seepage of 300 gallons per day per 100 foot of structure. About half that seepage is expected through the jet grout plug. If the higher rate of seepage occurs, it may last for several days or weeks during the period of time that the contractor is searching for the source of the leak and making repairs.

The project alignment should be divided into segments of about 150 feet by temporary transverse divider walls. These divider walls can be constructed of 2 or 3 rows of intersecting jet grout columns carried from the jet grout plug to a level above the water table. Each sector should be tested for leakage before excavation is carried below water level in any section. Excavation below the water table can be postponed until the desired water cutoff is achieved.

For the permanent condition, we have estimated seepage through the diaphragm wall panels, seepage through the invert slab (with and without waterproofing) and seepage through the joint between the invert slab and the diaphragm wall. Our estimate of maximum seepage is 50 gallons per day for 100 foot of structure with no membrane provided below the invert slab and 10 gallons per day with a membrane waterproofing provided below the invert slab. For this seepage estimate we have assumed that the transverse construction joint in the base slab is properly "water stopped" and that a third of the seepage occurs at the panel joint and at the wall/base slab joint.

Very truly yours,

MUESER RUTLEDGE CONSULTING ENGINEERS

By: ______________________
George J. Tamaro

Attachment
GJT:bee:da/9432/ltr-2

MUESER RUTLEDGE CONSULTING ENGINEERS	SHEET No. 1 OF
	FILE 9432
FOR RENO RAIL CORRIDOR	MADE BY GJT DATE 9/13/00
	CHECKED BY TC DATE 9/13/00

SUBJECT LEAKAGE ESTIMATES

CHECK OF BUOYANCY OF REINFORCED CONCRETE INVERT SLAB

ASSUME GWL @ -22', BASE OF SLAB @ -35', $\gamma_{conc} = 150$ PCF

IGNORE WEIGHT OF DIAPHRAGM WALLS.

WEIGHT OF INVERT SLAB = 6' × 150 = 900 PSF

UPLIFT FORCE = 13 × 62.4 = 811 PSF

FACTOR OF SAFETY = $\frac{900}{811}$ = 1.11 ✓ OK

CHECK OF BUOYANCY OF 14' THICK JET GROUT PLUG

BASE OF JET GROUT PLUG @ -49' $\gamma_{JET\ GROUT} = 130$ PCF

WEIGHT OF JET GROUT PLUG = 14' × 130 = 1820 PSF

UPLIFT FORCE 27 × 62.4 = 1685 PSF

FACTOR OF SAFETY = $\frac{1820}{1685}$ = 1.08 ✓ OK - FOR TEMPORARY CONDITION

MUESER RUTLEDGE CONSULTING ENGINEERS

FOR Rowo Rail Corridor

Sheet No. 2 Of
File 9432
Made By GT Date 9/13/00
Checked By TC Date 9/13/00

SUBJECT Leakage Estimates

PERMEABILITY ASSUMPTIONS

Item	K_{MAX}	K_{min}
Diaphragm Wall Panel	1×10^{-7} cm/sec 2×10^{-7} ft/min	1×10^{-9} cm/sec 2×10^{-9} ft/min
Invert Slab	1×10^{-7} cm/sec 2×10^{-7} ft/min	1×10^{-9} cm/sec 2×10^{-9} ft/min
Membrane Waterproofing	1×10^{-11} cm/sec 2×10^{-11} ft/min	
Jet Grout Plug	1×10^{-5} cm/sec 2×10^{-5} ft/min	1×10^{-6} cm/sec 2×10^{-6} ft/min

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FOR Rond Rail Corridor

Sheet No. 3 Of

File 943

Made By GT Date 9/13/00

Checked By TC Date 9/13/00

SUBJECT Leakage Estimates

Seepage Through the Finished Structure

Diaphragm Wall $h = 7'$ of Water $h_{AVG} = \frac{7'}{2} = 3.5'$

$t = 3'$ Area $= 7 \times 2 \times 100 = 1400$ SF

$$Q_{MAX} = A\frac{h_A}{t}k_{MAX} = 1400\frac{3.5}{3}(2\times10^{-7}) = 326.7\times10^{-6}\ FT^3/MIN/100$$
$$= 3.5\ GAL/DAY/100'$$

$$Q_{MIN} = \frac{Ah_A}{t}k_{MIN} = 1400\frac{3.5}{3}(2\times10^{-9}) = 3.26\times10^{-6}\ FT^3/MIN/100$$
$$0.035\ GAL/DAY/100'$$

Invert Slab (w/o Water Proof) $h = 13$ $t = 6$ $A = 54\times100 = 5400$ SF

$$Q_{MAX} = \frac{Ah}{t}k_{MAX} = 5400\frac{13}{6}(2\times10^{-7}) = 2340\times10^{-6}\ FT^3/MIN/100'$$
$$25.2\ GAL/DAY/100'$$

Invert Slab (w/ Water Proof) $h = 13$ $t = 0.01$ $A = 54\times100 = 5400$ SF

$$Q_{MIN} = A\frac{h}{t}k_{MIN} = 5400\frac{13}{0.01}(2\times10^{-11}) = 140\times10^{-6}\ FT^3/MIN/100'$$

Summary	MAX	MIN
Wall	3.5 GPD/100	0.035 GPD/100
Slab	25.2 GPD/100	1.5 GPD/100
Vert Joints	Leaks Sealed	No Leaks
Horiz Joints	10 GPD/100	No Leaks
Total	38.7 GPD/100	2.0 GPD/100'
	Say 50 GPD/100	Say 10 GPD/100'

SUBJECT LEAKAGE ESTIMATES

SEEPAGE THROUGH TEMPORARY STRUCTURE

DIAPHRAGM WALL – $h = 13$ $h_{AVG} = 6.5$ $t = 3$ $A = 13 \times 2 \times 100 = 2600$

$Q_{MAX} = A \frac{h}{t} k = 2600 \frac{13}{3} 2 \times 10^{-7} = 2253 \times 10^{-6}$ FT³/MIN/100

24.0 GAL/DAY/100'

$Q_{MIN} = 2600 \frac{13}{3} 2 \times 10^{-9} = 22.5 \times 10^{-6}$ FT³/MIN/100

0.24 GAL/DAY/100'

JET GROUT $h = 27'$ $t = 14$ $A = 5400\ FT^2$

$Q_{MAX} = 5400 \times \frac{27}{14} \times 2 \times 10^{-5} = 208{,}286 \times 10^{-6}$ FT³/MIN/100'

= 2222 GAL/DAY/100'

$Q_{MIN} = 5400 \times \frac{27}{14} \times 2 \times 10^{-6} = 20{,}829 \times 10^{-6}$ FT³/MIN/100'

222 GAL/DAY/100

SUMMARY	MAX	MIN
WALL	24 GPD/100'	0.24 GPD/100'
VERT WALL JOINT	720 GPD/100	
JET GROUT	2222 GPD/100	222 GPD/100'
HORIZ JOINT BTWN WALL & JET GROUT	1000 GPD/100'	100 GPD/100
	3966 GPD/100'	322 GPD/100
TOTAL	SAY 4000 GPD/100	SAY 300 GPD/100'

MUESER RUTLEDGE CONSULTING ENGINEERS

SHEET NO. 5 OF
FILE 9432
MADE BY GJT DATE 9/13/00
CHECKED BY TC DATE 9/13/00

FOR Route Rail Corridor

SUBJECT Diaphragm Wall & Invert Slab Leakage Estimate

CHECK OF "ACCEPTABLE" LEAKAGE - GERMANY "STANDARDS"

GERMAN STANDARD LEAKAGE RATE = 1 LITER/SEC/1000 m²

1 LITER/SEC/1000 m² =

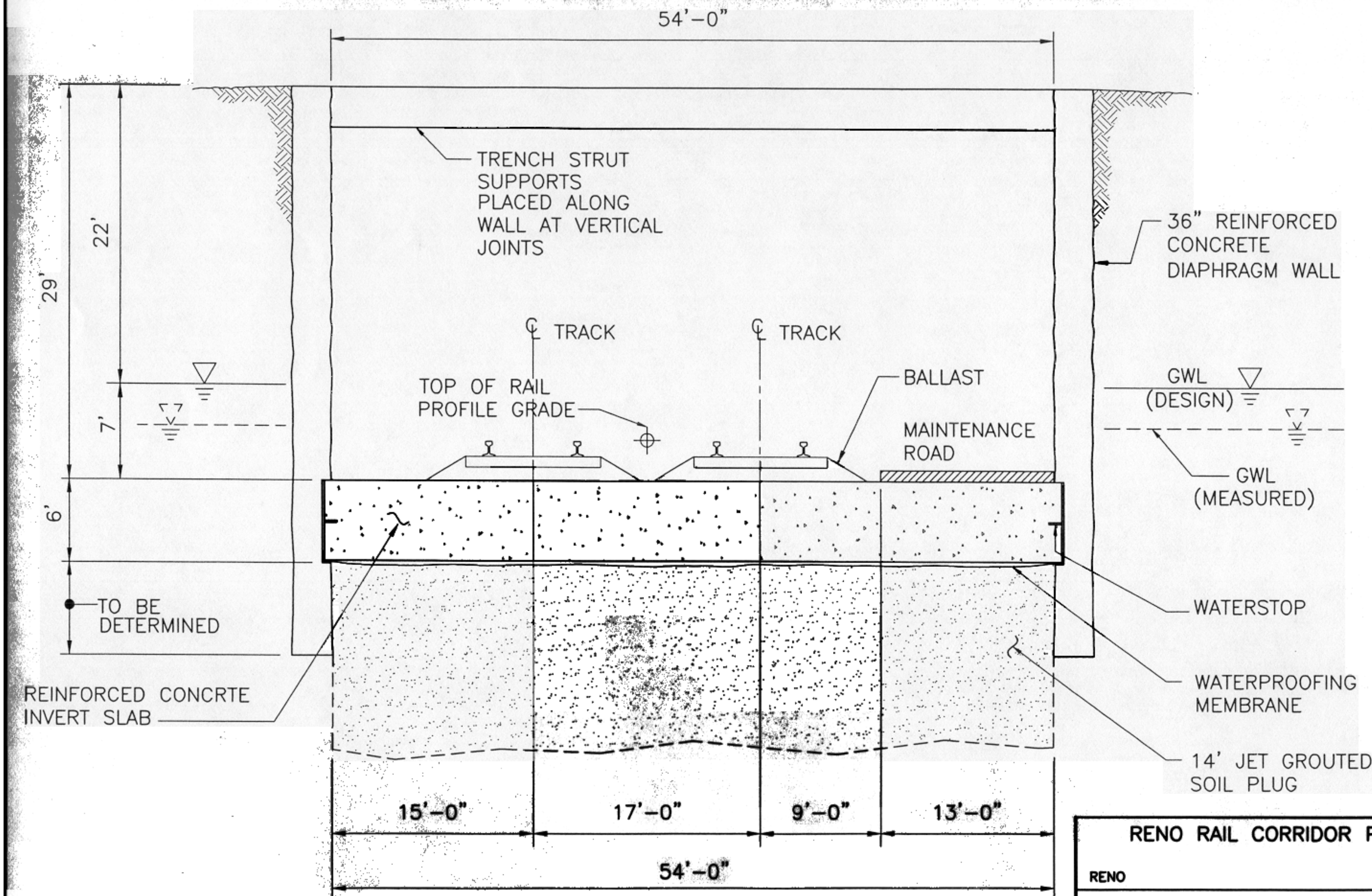
1 LITER = 0.26 GAL   1000 m² = 10,758 FT²

$$l/s/1000m^2 = \frac{0.26\,GAL \times 60 \times 24}{10,758} = \frac{374\ G/DAY}{10,758\ FT^2}$$

$$= 0.035\ G/DAY/FT^2$$

FOR CONSTRUCTION $A/_{100'} = (13 \times 2 + 54) = 8000\ FT^2$

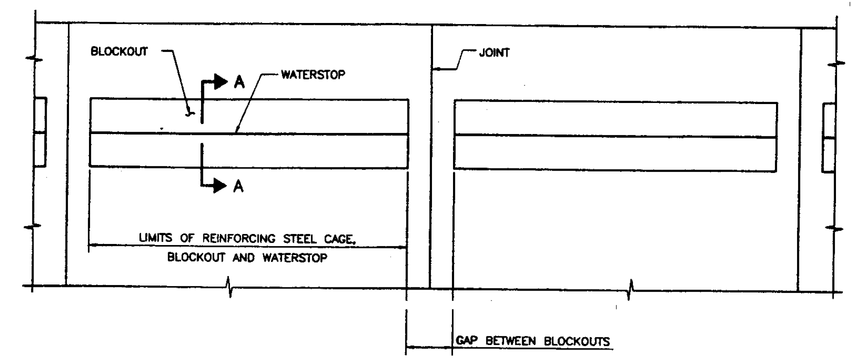
$Q = 0.035\,(8000 = 280\ G/DAY$

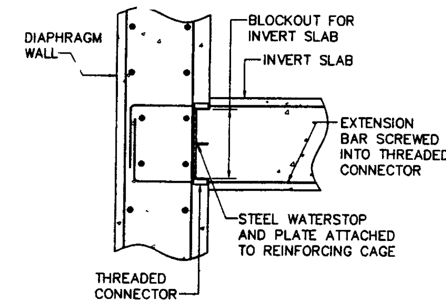


DIAPHRAGM WALL WITH REINFORCED CONCRETE INVERT SLAB

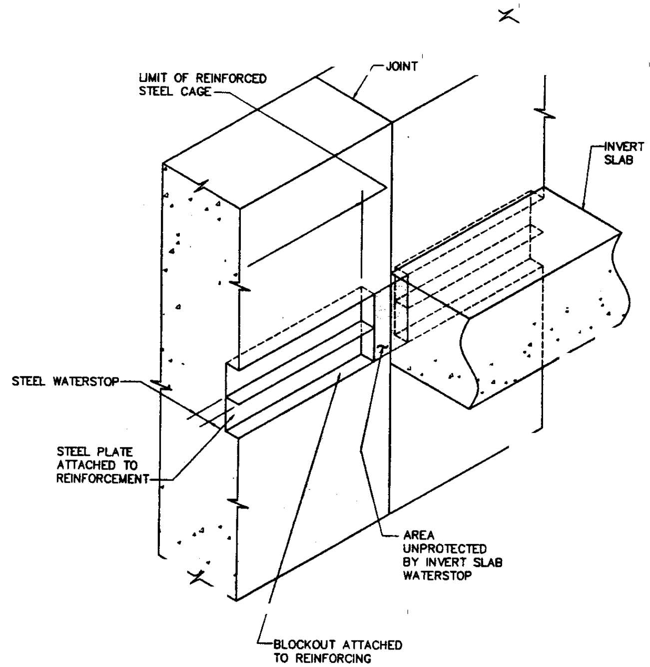
SCALE: 3/32"=1'-0"

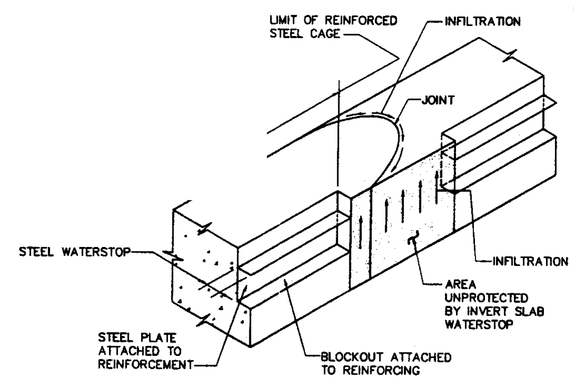
RENO RAIL CORRIDOR PROJECT			
RENO			NEVADA
MUESER RUTLEDGE CONSULTING ENGINEER			
708 THIRD AVENUE, NEW YORK, N.Y. 10017			
SCALE N.T.S.	MADE BY J.R. / CH'KD BY G.J.T.	DATE 9-11-00 / DATE 9-11-00	FILE NO. 9432
DIAPHRAGM WALL AND INVERT SLAB			DRAWING NO. D-1



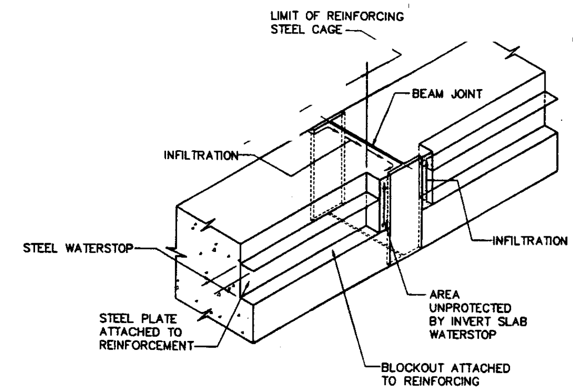


SECTION A–A

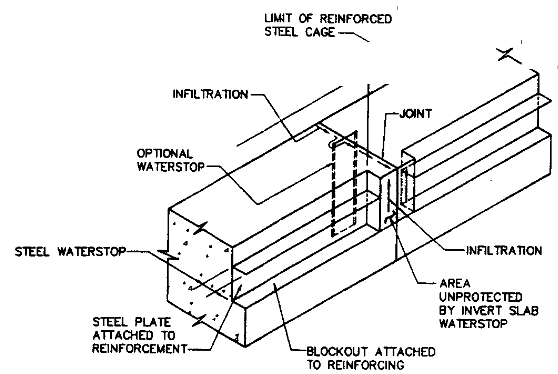




ROUND JOINT FORMED WITH END STOP PIPE



STEEL BEAM PANEL JOINT



SQUARE JOINT WITH WATERSTOP

RENO RAIL CORRIDOR PROJECT			
RENO			NEVADA
MUESER RUTLEDGE CONSULTING ENGINEERS			
708 THIRD AVENUE, NEW YORK, N.Y. 10017			
SCALE N.T.S.	MADE BY J.R. / CHK'D BY G.J.T.	DATE 9-11-00 / DATE 9-11-00	FILE NO. 9432
DIAPHRAGM WALL CONTRUCTION WATERPROOFING DETAILS			DRAWING NO. D-2